METHODOLOGY FOR PARTICIPATORY MODELLING: CITY LOGISTICS AS A USE CASE

Work in progress

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Objective of the paper: This paper seeks to develop a methodology for participatory modelling in the context of a decision related to a “wicked” problem. It is designed to have a deeper integration of stakeholders during the construction of a model to leverage their expertise and build trust towards the model.

Research design, methodological approach: The literature on participatory modelling is reviewed and workshops have been carried out with students and professionals to design and to test the methodology. The idea of the methodology is to put participants as actors of the modelling exercise, in order to do so, the model should always as simple as possible so that everyone can understand, verify, and use the model to share their expertise, constraints, or objectives. The methodology proposes to leverage the use of interactive simulation model allowing the participants to generate and to evaluate their own scenarios. For the workshops, the participants were asked to evaluate the impact of five different regulations in a city on restaurants and on parcel deliveries. Three workshops have been organized to observe if participants could master new modelling skills and use those skills to transfer their expertise towards others. Direct observations, questionnaires and group discussions were used for this evaluation.

Results obtained: The workshops have shown that the participants were interested to be an actor of the model construction, they were eager to challenge the model at hand. Although models are often used in organizations to support decisions, the workshops highlighted that the participants were not always comfortable with the modelling exercise and the limitations of what is often seen as a “rational” method.

Theoretical contribution of the paper: In this paper, we propose to introduce the concept of intersubjectivity to address wicked problems. In these types of situations, all the stakeholders have legitimate objectives that can be contradictory, however, sharing and explaining them could pave the way to trade-offs or the development of innovative solutions. The construction of the model becomes a support, where everyone attempts to fit their subjectivity to create a unique and a coherent representation of the problem.

Managerial contribution of the paper: Managers can use the methodology to think about a problem with different stakeholders. The strength of the methodology is the fundamental willingness to include everyone to answer a question. The methodology is thought to use interactive tools to help participants to make sense of the model.

Limitations of the work carried out: Although the methodology has not been implemented yet in the context of a real decision, two main limitations can be foreseen. First, the selection of the participants is subjective and subject to practical constraints. For each organization, two different profiles would be needed: someone from the operations to have a clear view of how it’s done, and another one from management to have the strategy perspective. Secondly, the exercise of transparency can be difficult in a competitive or a political environment.

Keywords: participatory modelling; city logistics; interactive simulation

1 INTRODUCTION

Several authors (Näslund, 2002; Singh & Burgess, 2013) are considering that the academic field of supply chain will be constrained in its development unless it opens towards other ontological and epistemological propositions. This paper presents a methodology for modelling a multi-stakeholder problem in a participative paradigm (Towers & Chen, 2008). As proposed by Towers & Chen (2008), this paradigm considers human beings as co-creating their reality through participation that can contribute to a better understanding of influencing factors in a supply chain. In a recent work, Fabbe-Costes et al. (2020) recently showed through the example of supply chain mapping that a subjective representation can be a useful tool for inter-functional and inter-organisational collaboration.

The objective of setting up a participatory approach is threefold (Mendoza & Prabhu, 2005). First, the stakeholders share their business knowledge, compare their vision and their experience of a problem. Second, the integration of stakeholders in the decision-making process can lead to a feeling of greater commitment to a better acceptance of the decision. Third, the credibility of the model is reinforced by the diversity of stakeholders, especially for those affected (but not decision-makers) by the decision.

In the context of city logistics, where decisions involve stakeholders (city, shipper, resident, carrier, etc.) with contradictory representation of a problematic, a participatory approach has been implemented several times. First, it has been used to collect information and knowledge. Residents in the United Kingdom (Yearley et al., 2003), experts in their own experience of urban life, were invited to express themselves to acquire local information on their perception of urban logistics and its negative externalities (pollution of air, noise and odour nuisance). Secondly, it can be used for model validation. Anand et al. (2016) compared the decisions of a simulated agent to a domain expert to validate the simulation. Thirdly, it can be used to build consensus about key performance indicators. Morana & Gonzalez-Feliu (2015) used a participatory method to select 7 main indicators and 9 secondary indicators to build a dashboard dedicated to sustainable city logistics.

In this paper, we propose a methodology that would cover those different uses. Indeed, a participatory method should not have silos, otherwise participatory method loses their added value and credibility. For example, once the information is collected from users, they should be able to check if their opinion is well depicted. Or one can challenge the validation of a model that would be only based on the observation of its outputs, and not its internal mechanisms (the main criticism against machine learning).

In a collaborative context, we are interested in how stakeholders could confront their subjectivity when facing a common problem. Our methodology invites stakeholders to share, explain, and discuss their objectives, constraints, and values. The methodology revolves around the mastery of a model by the stakeholders. This mastery would offer stakeholders the opportunity to have a reflexive approach about a simulation model (generally used in quantitative approaches), so it could be used as a mediating tool to develop a qualitative approach when discussing ambiguous concepts (e.g., equity, fairness) inherent to supply chain challenges when related to social and environmental issues. The goal of the paper was to assess the participants' capacity to engage in a modelling exercise.

2 METHODOLOGY

In our approach, we want the stakeholders to master the model, so that it can be "realistic" (in depicting the perspective of each stakeholder) and trusted. As the participants (representant of stakeholders) are probably not familiar with modelling techniques, our methodology aims at filling this gap with two fundamental concepts: iteration and interaction.

The validation of a large simulation is a daunting task for experts in modelling (Sargent, 2013), therefore it would not be wise to ask participants to tackle this challenge without any help. In our methodology, we propose to involve the participants in the modelling through time. The process starts with a simple (naïve) model. The simplicity has two virtues. First, it is easy to teach modelling basics to the audience. Second, it aims at triggering critics about the model from the participants. Building upon knowledge transferred towards the participants about modelling skills, and toward the model about the domains of expertise, the model can be improved. The model expert uses the feedback from the participants to improve the model towards a common representation. From one workshop to another, the model will progressively gain in complexity to represent the subjectivity of everyone. Following this incremental process, the participants' efforts to build and to validate a large simulation model is split into reasonable work/cognitive loads, while the model expert can leverage their expertise in the meantime. In this process, the use of interactive simulation helps the participants to explore the model by testing hypothesis or scenarios. It is meant to help the learning phase, but also later to support ideas during group discussion. The result would be what we call an open model: a model accepted by all the participants and where the domain of applicability is clearly known by them.

2.1 Interactive simulation

We proposed to use a simple model to allow a novice in modelling to understand the model. But oversimplifying a model also presents the risk of forgetting an important operational constraint. Thanks to interactive simulation, we are looking for helping novice to handle a model complexity. There are few interactive tools allowing users to participate in a reflection on the constraints of urban logistics. We can cite the work of Guerlain et al., (2016) which offers an interactive and tangible support allowing users to interact around a table on a simulation model. The interest in interactivity is twofold.

First, it makes it possible to engage users in the design process by a roundabout means: learners prefer interactive simulations to traditional teaching methods (Vogel et al., 2006). The first contact of users with the model can be made through interactive exploration rather than by analyzing the equations of the model. The experiments have shown that the participants appreciate the ludic aspect and the novelty of this type of tool.

Second, interactivity would allow cognitive gain (Vogel et al., 2006) for users. This potentially opens the way to the use of more complicated models: models potentially capable of better representing reality or of testing hypotheses. It has been shown that interactive simulation can be an effective way to solve difficult problems. For example, the serious game "phylo" makes it possible to mobilize the human capacity to solve hard (NP-complete) model alignment problems (Kawrykow et al., 2012) for comparative genomics.

In conclusion, we formalize the interest of interactive simulation as a way to motivate users to participate in the design phase and to facilitate the use of more complicated models.

We have established that the quality of a decision support system depends on the validation of a model, here defined as its acceptance by the various stakeholders for whom it is intended, and on its use by decision makers. The stage prior to these validations is the understanding by the users of the model: this is the objective that we give to the interactive simulation. We mean "understanding of the model" by the internalization by users of what the model represents and, equally important, what it does not represent. In the context of using an open model with interactive simulation, understanding "what the model does not represent" is a founding principle.

Let's focus first on the final objective: the validation of the model and its use. Users participate in the validation by ensuring that their various business knowledge is present in the model. For this, they must have a sufficiently detailed knowledge of the model: they must become experts in the model. So what is an expert? Using a trivial definition, we can say that it is a person who has some knowledge of a domain and will therefore be able to give a reliable answer to a question about it. The expert knows how to answer questions about his area of expertise and give an index of confidence. But the expert also knows how to identify issues at or outside his area of expertise. In this case, he will give an opinion with precautions or will direct the interested parties to the experts concerned. The same goes for the new model experts: they must be able to identify the questions to which the model can provide an answer and with a confidence index.

Often a model may not provide a satisfactory answer to a particular question. It is the knowledge of the model's shortcomings that will allow users to understand that it must be improved. We insist on what the improvement must be done towards the final objective: the validation of the model and its use, and not the exact representation of phenomena. In other words, the model must remain accessible in terms of complexity to users so that they are able to offer reliable answers. We want to show that faced with a model flaw, the question is not necessarily "how to model this constraint / parameters / decisions?", but rather "what cost will we have to pay for this improvement?".

It can be a human cost to code the improvement or a financial cost to purchase additional data. But we consider that the main cost will be rather conceptual: a more complex model with the risk of losing the benefits presented above. Experiments have shown that the complexity of a model quickly exceeds the cognitive gain offered by interactive simulation. We must therefore resist the (futile) temptation to use interactive simulation to explain a "gas factory". Rather, we need to be reassured about the human capacity to solve hard problems satisfactorily (even if not optimally), by being assisted by imperfect tools. In the context of transport, human can come up with satisfactory solutions without computer assistance to the NP-hard problem of the Traveling Salesman Problem for small instances (Best, 2005). If users have sufficient analytical capacity, why include analysis in the model at the risk of complicating it? The idea behind interactive simulation is to leave the calculations (complicated and off-putting) to the computer to leave more room for the user in the analysis.

Interactive simulation unveils the model: users can make a relatively complex model their own by experimenting with different scenarios and visualizing the impacts on the simulation results. In fact, it also brings to light the apparent failings of the model. Faced with an interactive simulation, users quickly understand that an open model is a very partial representation of phenomena. We present this obvious lack of modelling expertise as a permanent stimulus on the consciousness of users (and their subconsciousness) to question the model and weight its responses.

Figure 1: Example of an interactive simulation with customizable variables (on the left side) and display of the simulation outputs (on the right side)

2.2 Experimentations

In the previous section, we showed the relevance of the concept of open model and interactive simulation to allow participants to better appropriate a model. In this section, we describe an experiment the aim of which was to evaluate the possibility of creating a consensus on the model between users. We recall that the objective of this process is to arrive at a consensual solution by relying on the involvement of all stakeholders. To arrive at this consensual solution, it is necessary for the group to agree on the estimated impacts of different possibilities, and to compare them to retain the most satisfactory one. In other words, users must build, understand, and validate the model used to make the impact estimates.

The same workshop has been held twice with different publics. The first public was composed by students in engineering, while the second was composed of professionals related to city logistics issues (city representative, shippers, retailers, supply chain consultant, car manufacturers). The participants were asked to reach a consensus in the estimation of the impact of five different regulations (e.g., diesel ban) in a city on two supply chains : restaurants and parcel deliveries. Direct observations, questionnaires and group discussions were used to evaluate their understanding of the model, the relevance of the model to create discussions, the use of the model to support an argument, or show a critical approach of the model, propose improvements of the model. For the workshops, a simulation model accessible through an interactive interface was proposed (as shown in figure 1).

The experiment was divided into three main stages during which we assessed their opinion in relation to the effects of regulations and confidence in their responses in the assessment of the impacts. In the first step, we asked users to individually study the problem to make their estimate. This step was guided by a questionnaire to which they had to answer. In the second step, users had access to the interactive simulator to estimate the impacts. And in the third step, a group discussion to try to reach a consensus on the impacts was led by the animator of the experiment.

The main objective of the experiment was to test the methodology by allowing participants to take on the role of the designer rather than that of the user. We wanted to assess the user's ability to use interactive simulation to understand and challenge a proposed model. But in this experiment, we also wanted to assess the interest of the participatory component of the methodology to animate a discussion and to converge towards a common estimate of the impact of different decisions, and hopefully towards a common model. The breakdown into three stages was to make it possible to follow the evolution of users' responses by means of a questionnaire. After the first group, it appeared that the case study was too large to use the users' answers to the questionnaire: the questions (and therefore the answers) were too ambiguous. However, we kept the steps to facilitate the workshops, and we limited ourselves to a qualitative assessment of the different groups.

The first was composed of students having the same profile with a background in engineering. The second was made up of professionals (11 from the private sector and 1 from the public sector) close to urban logistics issues. We were thus able to assess the differences in behaviour between the different audiences. The objective was to test a method to familiarize users with the tool. The experimentation showed the difficulty of some users with the tool and the modelling concepts. By dividing the experiment into several stages, we wanted to present the modelling concepts and the interactive simulation tool more gradually.

2.2.1 Case study

Cities face complex regulatory issues. In fact, regulations are generally adopted at city level, but their effects are heterogeneous depending on the actors (shippers, carriers, customers, etc.)

and the sectors. The diversity of actors and sectors makes it difficult to estimate all the possible consequences following the implementation of new regulations. Hence the interest of a participatory modeling approach to ensure the relevance of a regulation whose objective is generally macroscopic (i.e. reduction of polluting emissions) while the effects materialize at the microscopic scale (i.e. new constraints for the logistics schemes in place).

We propose to limit the problem to a use case considering the point of view of carriers on five strategic trends within the city. For users, the objective is to estimate the impact of each trend on two urban logistics sectors: e-commerce delivery and restaurant deliveries. These two transport activities were chosen because of the clear difference in their logistical organizations, for example the constraints of the customers and the vehicles used.

We have identified, at a strategic level, five trends representative of potential actions at the level of a city. Strategic trends are sometimes defined in a vague way (what is a "truck"? How to estimate the reduction in consumption?) In an attempt to bring out different interpretations between users. The different strategic trends are:

- Vehicle size: ban on trucks.
- Time windows: deliveries only authorized between 9:00 a.m. and 11:30 a.m.
- Land reserve intended for logistics: distance of the warehouse from the location of the demand.
- Engine: only EURO 5 and 6 engines are authorized.
- Sustainable development: customers are encouraged to reduce their consumption.

2.2.2 Model

In the first step, users will be led to think about how to assess these strategic trends. In the second and third stages, the trends will be assessed against the performance indicators presented in the following section.

The model proposed for the workshop is a vehicle routing problem with limited capacity. Insofar as the study takes place on a strategic scale, the hypothesis of carriers with an infinite fleet seems reasonable: carriers have the flexibility to modify the size of their fleet through subcontracting. The model is based on a geographic information system (from OpenStreetMaps) containing roads, customer locations and a warehouse.

The optimization model has two decision variables. The first decision variable is the location of the warehouse. The first choice is in Montrouge, just outside Paris. The second choice is located in Rungis (15 km from Paris), an industrial and commercial area well connected to Paris by motorways, but further away. The second decision variable is the type of vehicle. The optimization aims to minimize the total distance traveled by the fleet.

The performance indicators are calculated on the basis of the optimization results (the distance traveled by the vehicles in km) and modifiable parameters presented in the following section. We proposed to evaluate the regulatory measures from the point of view of carriers through three performance indicators:

- The first performance indicator represents the total financial cost of delivering 200 points.
- The second performance indicator corresponds to the average time of a delivery round. This represents the performance of the distribution in terms of execution time. If the

tour is short (ie fast) it is possible to deliver more during peak hours. For example, it becomes possible to deliver to all customers after working hours (between 6 p.m. and 8 p.m.).

- The third performance indicator aims to represent environmental performance by estimating the quantity of grams of CO_2 generated by vehicles.

These indicators are common to both sectors so as to be able to easily compare the effects of strategic trends on the two sectors in our case (e-commerce and restaurant), and to highlight the difference in impact between the regulations probably leading to different decisions. For example, deliveries to restaurants are subject to severe time constraints before lunch (between 9 a.m. and 12 p.m.). If the vehicles are already at full capacity, there is no apparent motivation to improve their speed of delivery, as it is not possible to deliver in the afternoon (not enough time in a working day) nor to use a larger vehicle (the vehicle would be more expensive and with a low filling rate). On the contrary, for e-commerce deliveries that can be made all day, the carrier can choose to lengthen the rounds with larger vehicles or to make several rounds per delivery, because the delivery person still has time to make deliveries other deliveries and fill the vehicle. On the other hand, the e-commerce carrier will also favor the small size of its vehicles to facilitate parking near delivery points.

These indicators were chosen for their relative simplicity and their known influence on the sectors. The obvious limitation is that the performance indicators may not be suitable for a certain type of activity. Therefore, participants are encouraged to think about modifying or adding performance indicators to improve the model.

2.2.3 Settings

The parameters are easily accessible through the simulator's graphical interface. The Figure 5 is a screenshot representing a given set of parameters for a simulation scenario.

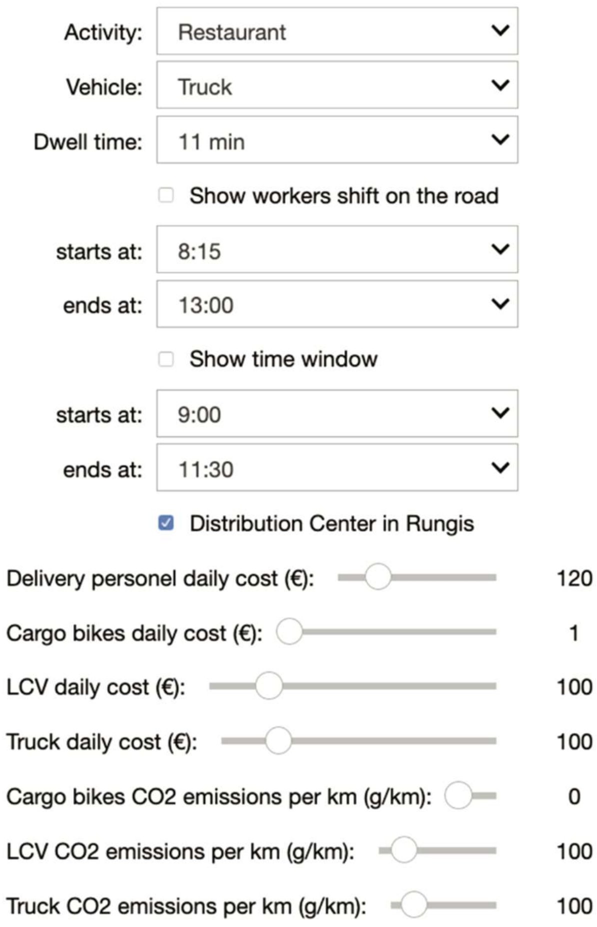

Figure 2: Interactive simulation parameters

The first parameter that the user can choose is the sector: restaurant or e-commerce. This choice will have an influence on the second parameter: the type of vehicle (cargo bike, utility vehicle or truck). Indeed, the capacity of a vehicle is modelled by the number of customers served. However, deliveries for restaurants are larger than deliveries for e-commerce. The capacities of the vehicles according to the sector and the vehicle are presented in the Table 1.

	Cargo bike	Van	Truck
Restaurants	1 customer	5 customers	15 customers
e-commerce	25 customers	50 customers	100 customers

Table 1: Loading capacities of the vehicles in the model

The third parameter is the average time to make a delivery: time required to park and deliver the delivery. The fourth parameter is the time at which the working day begins. Parameters such as the end of the working day, the start and the end of the window have no impact on the indicators. They are visual cues that make it easier for users to see if the working day is too long or if the tour encroaches outside the window. Then, a set of parameters relating to the daily costs of the different vehicles to estimate the performance indicator on the cost. Finally, a set of parameters controls CO2 emissions per kilometre travelled to estimate the environmental performance indicator.

	E-commerce	Restaurant
Number of serving customers	1 customer	5 customers
Location of the distribution center	Beaugrenlle	Rungis
Average delivery duration	2 min	11 min

Table 2: Deliveries' characteristics in the model for e-commerce and restaurants

3 RESULTS

In this experiment, we sought to assess the ability of users to take part in a participatory modelling process and to assess the differences between the types of users (neophytes and experts). The experimentation carried out on different groups (engineers who are not experts in urban logistics and experts in urban logistics but not necessarily engineers) made it possible to identify different understandings of the methodology relevance.

The presentation of the results will focus mainly on the written feedback of the participants, the observations and the discussions of the participants during the experiment. In this section, we will first present the participants' reaction to a modelling problem with an interactive simulation tool. Next, we will look at how the participants approached the concept of participatory modelling.

3.1 Interactivity and involvement in participation

The experimentation on neophyte group made it possible to highlight the link between the level of mastery of modelling concepts and expectations on the complexity of the model. Indeed, none of the neophyte participants had any in-depth knowledge of urban logistics issues. In the previous experiment using participatory modelling, we were able to note a significant disparity within the group in the mastery of the tool. This can be explained by the differences in curriculum of the group: only a part of the group was made up of engineering students with a certain ease with modelling concepts. Observations during this experimentation allowed us to confirm this intuition, since it was made up exclusively of engineering students who had no difficulty in appropriating the tool.

From there, we could see that those less comfortable with the tool would have liked more explanations on the model and the context. Conversely, the engineering students, whose comments show that they had integrated the principles of modelling well, wanted more parameters, that is, a more complex model.

This observation highlights certain difficulties. Participants need to have minimal mastery of urban logistics problem or modelling concepts. In cases where they have mastered the concepts of modelling, but not those of urban logistics, they seem to tend to focus on technical aspects, rather than on the objective of solving the problem through consensus. This was supported by the fact, for example, that one participant mentioned that he had difficulty using the proposed model, and that he would have preferred to create the model himself. We notice that while this participant has a highly technical level, since he would be able to create a model. Surprisingly, the participant was less comfortable with the tool compared to participants with a less technical background. We can then wonder if it is not because he wanted to change the perspective of approaching the problem. From a decision problem, he may have wanted to build a precise technical representation as it is usually taught in engineering schools.

Conversely, those less familiar with the tool will tend to focus on the problem, which they may find more understandable, which is illustrated by their request for more information about the problem. This request fits well into the participatory modelling approach, and into the experimentation as we conducted it. Indeed, the time for individual reflection, and the breaking down of the experience into three stages, paid off. Not only did we observe a greater participation at the end of the experiment, especially for the neophyte group, but the participants themselves expressed that they were more comfortable as the experiment progressed. On the one hand, a participant mentioned that he was able to clearly identify the problem thanks to the division of the experiment into several stages as well as the questions about the study. In addition, we also attribute this success to the individual time for reflection left to each, which initially allowed them to grasp the problem, removing the associated difficulty of grasping the tool.

Thus, we were able to observe that the smooth running of the process required prior knowledge, at least basic, of the problem. If this was not already acquired (as with the group of experts which we will discuss next), it could be thanks to a breakdown step-by-step experience, and considering individual thinking time, which allowed users to move forward at their own pace. They could thus reflect on their answers and build their arguments before speaking. However, a technical mastery of modelling concepts without prior knowledge of the problem of urban logistics could in some cases be a brake on the appropriation of the decision-making problem. Indeed, we have observed an unexpected risk, which is that they concentrate on what they know without succeeding in grasping the stakes of the problem and obtaining a vision of the problem. For a new experiment, it would be interesting to assess the participants' ability to integrate the process, if they have a double mastery, both technical modelling and the problem of logistics.

The comments of the neophyte group confirm the relevance of a participatory modelling approach. For example, one participant clarified that it is difficult to come to a definitive conclusion on the problem, but that the workshop opens the debate. This is an encouraging remark since the main motivation of the methodology is above all the exchange between stakeholders for the expression of their point of view. Of course, it was impossible for neophytes to comment on the validity of the model. Additionally, despite the fact that the more technically experienced participants tended to focus on the technical aspects of the problem, the participant who mentioned that he would have preferred to do the model himself also confirmed that he was inclined to invest in this task. Even if the objective of the experiment was not precisely this, we see as positive the fact that the process triggers a willingness to invest time in effort.

In conclusion, the experiments with the neophyte groups demonstrated that a basic individual understanding of the problem is necessary before being able to implement the use of an open model and that interactive simulation alone is not of interest for a neophyte audience.

Participants must be accompanied in a process where they are put in a situation and guided to the important questions.

The expert group generally considered the simulation model to be simple, although it was considered globally representative of the operations and constraints of the carriers. This conclusion indicates that the model, despite its simplicity (and therefore its accessibility), can be a tool to analyse urban logistics at least on general considerations. For example, the model illustrates the impact of vehicle capacity or the introduction of delivery schedules on carrier operations. On the other hand, the expert group did not comment on the validity of the model to address the issue of the case study.

At the end of the experiment, the expert group quickly aligned itself with proposals for improving the model. The experience has enabled them to identify additional metrics and performance indicators that they use for their operations. The group considered that to better respond to the analysis of different strategic trends, the model should contain the following parameters:

- The average weight delivered
- The average volume delivered
- The delay expected by customers (level of service)
- The notion of frequency of delivery

The group proposed the following performance indicators:

- The effective time for delivery
- Vehicle fill rate (available but not displayed, close to 90% in the scenarios)

A discussion of the appropriateness of these additions raised interesting modelling questions. The group considered it important to consider the notion of time to represent the frequency and the delivery time. The discussion did not decide whether this notion was essential to answer the questions in the case study. The difficulty of this arbitration shows participants the challenge of modelling. The model can be more and more complete, but this does not necessarily provide a better answer to the study question. We believe that the situation of the participants in the role of designer makes it possible to illustrate in practice the difference between the problem considered, the model created, and the decision support system.

This trade-off illustrates that increasing complexity by adding parameters or indicators is not "free". On the one hand, for the design, it is necessary to characterize these new elements and integrate them into the model. This is a source of additional work which must be justified by the expectation of greater utility of the model. And on the other hand, in the analysis, the model becomes harder to understand. A participant from the expert group said he was relieved to have to analyse a model with ultimately few parameters.

Despite the "simplicity" of the model, the modelling exercise is difficult. Much of the discussion crystallized for both groups on the interaction with simulation. The neophyte group appreciated the fun aspect of the tool and the ease of use despite a perfectible interface. The expert group also stressed the need to improve the interface. Much of the discussion with the expert group focused on the representation of performance indicators (e.g., representation on a map). The question of visualization made it possible to highlight that the interface was an important aspect to be considered for the tool. And like the model, the interface should be a topic of discussion for improvement. This is an important point to integrate into the methodology to involve the participants. It is not enough to select the right indicators, they must also be easily interpreted by users. This highlights the double level of difficulty: the tool models the problem, and through this modelling exposes this same problem to the knowledge of the participants.

3.2 Participatory modeling in a professional context

The discussion with the expert group was an opportunity to discuss the possibility of using this methodology in a professional context. It appears that this tool would rather be intended for discussions between experts for the study, and less for arbitration by the final decision-makers. Indeed, the modelling activity is time consuming, not to mention the negotiation to arrive at a consensual model. It was proposed that the final decision-makers could rely on their operational team for the realization and the validation of the model to arrive at the creation of several scenarios with the estimation of the impacts. The results of this work would not necessarily be presented through an interactive simulation, but in the form of a report and a presentation. Thus, the final decision-makers will carry out the negotiation and arbitration between different solutions on the basis of their experts.

Unfortunately, this proposal is likely to encounter methodological problems in the context of its actual use. To support this assertion, we will base ourselves on the discussions in the expert group. The workshop with the expert group was also the opportunity for discussions on urban logistics which are essential for participatory modelling. They illustrate the difficulty of an exercise of transparency vis-à-vis the actors themselves and towards the outside. We will evoke two discussions.

The first discussion revealed the lack of visibility on the objectives of other stakeholders. Indeed, to offer a solution that suits everyone, we must understand the motivations of each. It turns out that actors sometimes have contradictory objectives, and the latter have difficulty expressing them. We can assume three causes to explain this difficulty.

The first relates to the structure of the organizations involved in the discussion. The expert covers a limited area in the activities or the decision-making level of his organization.

The experts present were at an operational level, while the model was designed to be used at a strategic level. As in the neophyte group, the participants focused on technical aspects rather than building an overall vision. For example,, a logistics manager is not necessarily aware of the marketing or commercial issues specific to his organization. The involvement of the final decision-maker who has a broader vision of his organization in the participatory modelling process would limit this difficulty in integrating logistics issues with marketing and sales issues.

The second cause is the difficulty of quantifying certain objectives. For example, the notion of quality of life could be quantified by aggregating indicators such as purchasing power, social diversity, the number of kilometres of cycle paths, etc. But how important are each of these indicators to quality of life? Moreover, these considerations will vary according to the city, the country, and the political power in place.

The third cause concerns the political nature of the definition of objectives. This seems even more significant in the case of a city where officials are regularly assessed during elections. For example, the clarification of objectives and priorities makes their authors responsible for their actions. The risk of a solution failing and having to be held responsible pushes towards a status quo. Let us quote the example of Simon (1990) on the possibility of diverting a hurricane to save a city: “If the decision maker does nothing, he can hardly be held responsible since it is a natural disaster”. On the other hand, if it does deflect the hurricane, and unfortunately the latter devastates a neighbouring town, then the decision-maker becomes responsible. This decision-maker is encouraged to maintain the status quo so as not to incur liability.

The second discussion highlighted the risk of delegating strategic decisions to external bodies viewed as experts. This example reminds us that the appointment of an expert requires prior expertise to ensure the quality of a consulting firm. Participants discussed the experience of a municipality using a consultancy firm to assist the city with regulating access to city delivery vehicles. The municipality was preparing to ratify decisions preventing a carrier from delivering during off-peak hours, an apparently virtuous initiative on the part of the professional. The consulting firm apparently did not get involved enough on the ground and did not go out to meet professionals to learn about their initiatives. This discussion reveals a lack of knowledge of the municipality in the field of urban logistics which was about to base their decision on "relative" expertise. Outsourcing a study is not a problem, but the city should be able to critically analyse a study that touches on an essential function of the city. This discussion shows the interest of developing knowledge on modelling and urban logistics towards local communities (and citizens) to have the necessary perspective in the evaluation of modelling work.

Considering the discussions, the proposal made during the workshop for the delegation of the analysis to groups of operational experts or groups of consultant experts is akin to a delegation of the decision. When studying a complex system, it is necessary to recognize this tension. If the delegation of the decision is effective, we run the risk of reaching only a local optimum: the decision is good for the problem studied but the impacts on other problems (housing, social integration, etc.) are not considered. On the other hand, the analysis will hardly be waterproof to the decision. We can illustrate this lack of waterproofing in this workshop: the proposal was precisely to submit different scenarios to the decision maker. By limiting the choice, don't the scenarios already constitute a form of decision made by the analyst? This example shows that the question of the boundary between analysis and decision deserves consideration in the decision-making process of an organization.

Of course, this responds to a pragmatic approach, because the decision maker does not necessarily have the time to conduct a full analysis of a problem. However, regarding the cost of a bad decision, shouldn't the decision-maker reconsider the priorities? Or be entrusted with more important means to achieve its mission? The tension on the issue of delegation effectively questions our ability to use modelling tools, but also the organization of decision-making.

4 CONCLUSION

Our methodology is meant as support consider a problem through a participative paradigm and develop new ways to consider a supply chain challenge. It could become an operational tool for managers or researchers to think collectively about a specific problem with different stakeholders.

The experiment made it possible to identify the different uses of this approach depending on the audience. For the neophyte public, it is necessary to support them more to compensate for their (legitimate) ignorance of urban logistics. In addition to supporting the participants on the concepts of modelling as we mentioned during the first experiment, they must be trained in management tools to present the concept of performance indicators. For the expert audience, the methodology has shown its interest in serving as a common basis for conducting a discussion. However, the workshop illustrated that the modelling exercise remains difficult. For example, some participants had difficulty grasping the multi-objective nature of a decision. The experiments identified new prerequisites to ensure that users were given the means to participate in the workshop.

The experiment showed that the methodology allowed participants to grasp the problem. On the other hand, experience feedback shows that participants must accept not to focus on technical aspects to move towards an abstraction necessary for a strategic decision. This conclusion calls for a modification of the methodology for demonstrating the limitations of a complex model to motivate participants to use a simple model.

Then, the exchanges between the participants made it possible to highlight the tension between the delegation of the analysis and the delegation of the decision on the part of the decision-maker to the operational teams.

Finally, the discussions highlighted the importance of visualization, an importance calling for collaboration with specialists in user interface ergonomics.

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